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AUTHOR Shimada, Shoko: And Others
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ABSTRACT

The purpose of this study was to cross-sectionally and longitudinally examine the developmental process of search behavior in infancy. Subjects were 23 Japanese normal infants (11 males and 12 females) who were individually tested once a month from the age of six to 13 months in laboratory settings. Small toys and three white opaque cubic boxes were used as hidden objects and covers, respectively. The subjects' spontaneous search behavior was observed after hiding a toy under one of the three boxes on a table. Fixation time to either of the three boxes was measured, and the entire procedure was videotaped. Cross-sectional data revealed the general developmental process of search behavior. Results indicate that the developmental process of search behavior is from nonmanipulation despite fixation to trial and error manipulation and then to goal-orienting manipulation. However, more than half of the subjects fell in a Redundant pattern of development. Males' search levels were significantly higher than females' at 6, 7, 9 and 11 months of age. These findings and additional results were discussed in relation to previous studies on object permanence and general cognitive development in infancy. (Author/RH)

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RRB-11

Development of Search Behavior through Visual Representation in Infancy

Shoko Shimada, Kyoko A. Iitaka, Yoko Wakaba

Yumiko Kai, Toshiko Y. Kamizono

and

Ryogoro Sano

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The Research Institute for the Education of Exceptional Children

Tokyo Gakugei University

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DEVELOPMENT OF SEARCH BEHAVIOR THROUGH VISUAL REPRESENTATION IN INFANCY

Shoko Shimada, Kyoko A. Iitaka, Yoko Wakaba, Yumiko Kai, Toshiko Y. Kamizono

The Research Institute for the Education of Exceptional Children

Tokyo Gakugei University

and

Ryogoro Sano

Well Babies Clinic, Kosei Hospital

Among the previous studies on cognitive development, the confirmation of visual representation in early infancy was reported by Fantz (1964), Friedman (1972, 1974) and others (e.g. a review by Cohen & Gelber, 1975). Fantz found it in the 2-3 month olds and Friedman in the newborns.

As opposed to the results by Friedman, Kagan (1971) suggested a fixation time of infants prior to 2 months of age was determined by a high rate of changes in physical characteristics of stimuli rather than by their acquired cognitive structure. In addition, he pointed out that infants' fixation time was influenced by their cognitive structure after 2 months of age, more clearly around 6 months, and then a new class of cognitive structure began to dominate as a determinant after about 9 months. Through a series of experiments, Kagan and his associates revealed that the cognitive development of infants was most activated around the end of the first year.

On the other hand, even in natural settings, it is very often observed that infants crawl to search for a hidden toy from about 9 months of age. This behavior can be regarded as the reflection of infants' cognitive development with reference to the findings by Kagan. In fact, Piaget (1954) described his observations on infants' development of object permanence

relating to intellectual development in general. According to Piaget, infants began to play a kind of game of hide-and-seek between 5 and 7 months and were able to recover a hidden object from around 8 months in the case of only a single hiding place, but not on the occasion of two. They search for an object in the place where previously found, ignoring the place where they saw it hidden until about 12 months.

However, Uzgiris & Hunt (1975), who formed an ordinal scale from Piaget's observations, reported even the 7 month olds could find a hidden object in the case of two or three hiding places. Thus, there is a big gap in terms of the age of infants who can seek correctly for a hidden object at multiple positions.

Therefore, this study was aimed to cross-sectionally and longitudinally examine the developmental process of search behavior through visual representation of infants in laboratory settings.

METHOD

1. Subjects

The subjects were 23 Japanese firstborn normal infants (11 males, 12 females) from middle-class families. They were selected from the record of Well Babies Clinic at Kosei Hospital in Tokyo where they were examined monthly in reference to their neurological, physical and psychological development.

2. Period and Place

The subjects were individually tested at the rate of one session per month from the age of 6 months to 13 months (7 were tested from the age of 7 months). The experiment was conducted in a quiet small room at the

institute without any equipment excepting materials and equipment needed for the experiment. The room was divided into two parts by a cream-colored thick curtain with screens for observing and videotape recording.

3. Materials

Several small toys and three white opaque cubic boxes made of cardboard (9 x 9 x 9 cm) were selected as hidden objects and covers, respectively. The set of small toys was varied from subject to subject according to their interests, the information of which was given by their mothers prior to each session.

4. Procedure

The subject sat on the mother's lap at a table and the mother was instructed to keep her infant at the midline of the table. A female experimenter placed several toys on the table close to the subject. While the subject was manipulating the toys, the experimenter set the three boxes, 15 cm apart from each other on the table within a reaching distance from the subject. The middle location was a little bit farther from the subject so that the three boxes were equidistant from the subject. The experimenter removed the toys one by one leaving the one the subject was manipulating, then took it from the subject and hid it under one of the three boxes, confirming the subject's fixation to it. The mother was instructed to restrain her infant's arms with her hands until the toy was completely hidden. The subject's spontaneous search behavior was observed for 25 seconds. Each session was composed of three trials and the hiding place was varied at each trial. The order of the hiding place was counterbalanced across sessions.

5. Recording

Two trained observers started to independently measure with electric event recorders the subject's fixation time to either of the three boxes immediately after a toy was completely hidden, and the whole procedure was videotaped. The tape was copied at 1/100 sec time intervals. The two observers cooperated to describe the subject's search behavior with a given form based on the records of fixation time and copied videotape recording.

RESULTS

1. Confirmation of Visual Representation

This term is defined in Table 1. The longitudinal data indicates that the mean and the range of the Confirmed month are 6.8 and 6-8 months, respectively. The mean of the males is slightly smaller than that of the females, but not significantly (Table 2).

2. General Process of Development in Search Behavior

Search behavior was categorized into three groups, level I, level II, and level III. The definition of each level is shown in Table 1. Since the level was varied at a trial in most of the subjects until 11 months (about 30% of them per month), the data was cross-sectionally analyzed based on trials across the subjects. The data from the first two trials in each month was used for the analysis as a general rule. Scoring 3, 2 and 1 for level I, level II and level III, respectively, and then plotting the mean score of each month forms Fig. 1.

Fig. 1 shows that the level of search behavior is proceeding from III to I with increase in age. In other words, the results indicate that the developmental process of search behavior is from nonmanipulation despite

fixation to trial and error manipulation and then to goal-orienting manipulation in general.

The males' levels are significantly higher than the females' at 6, 7, 9 and 11 months of age ($p < .05$, one-tailed). These results emerge because the females' ratios of level III for trials at 6, 7 and 9 months are significantly greater than the males' (6 months: CR = 1.894, $p < .05$; 7 months: CR = 2.560, $p < .01$; 9 months: CR = 1.826, $p < .05$; one-tailed) and the ratio of level I at 11 months is significantly higher in the males than in the females (CR = 1.837, $p < .05$, one-tailed).

3. Developmental Patterns

As mentioned above, most of the subjects' levels at each trial were varied until about 11 months in spite of the general tendency of development. Three relatively distinctive patterns in the development emerged: (a) Sequential: the same level occurred at the first two trials of each month and the level itself was upward with increase in age; (b) Stepped: one level lower occurred at one of the first two trials, but not at both; (c) Redundant: one level lower at both or two levels lower at one of them occurred. 14 of the subjects held enough data for judgement of patterns. 2, 3 and 9 of them fell in the Sequential, Stepped and Redundant patterns, respectively. Modal developmental patterns are shown in Fig. 2. The results suggest that more than half of the subjects' patterns are the Redundant.

4. Initiation and Establishment in Level I of Search Behavior

The terms are defined in Table 1. The longitudinal data indicates that the means of Initial and Established months in level I are 8.5 and 10.6 months of age with the ranges of 6-11 and 8-13, respectively. The

males' results show slightly earlier months in both than the females', but without any significance (Table 2). 2 of the subjects (one for each sex) could not reach to the Established month by 13 months of age.

There is a discrepancy among the three months of Confirmed visual representation, Initial and Established level I. The results are mainly due to the repeated occurrences of level II across months in most of the subjects. The ratio of each level for the sum of trials prior to the Established month of level I was calculated in 18 of the subjects whose lack of data was less than 2 months. Their mean ratios of level I, level II and level III are 29.84% (SD = 15.82), 48.25% (SD = 18.50) and 21.99% (SD = 22.57), respectively. The ratio of level II is significantly higher than that of either level I or level III ($t = 3.119$, $t = 3.724$, $df = 17$, $p < .005$, one-tailed).

5. Rank-Order Correlations

Rank-order correlations were calculated among the Confirmed month of visual representation, the Initial and the Established months of level I, and DQs* at 6 and 12 months. Sample size was 11 of subjects (8 males, 3 females) whose data was complete enough for judgement in each variable. The results are shown in Table 3.

The significant positive correlations are found between the two DQs, and between the Confirmed month of visual representation and the DQ at 6 months of age ($r = .571$, $r = .545$, $p < .05$, one-tailed). The Confirmed month

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* DQ (Developmental Quotient) was measured by MCC Baby Test (Koga, 1967) which was modified from the Measurement on Intelligence of Infant and Young Children (2nd ed.) by P. Cattell (1960).

of visual representation is also relatively correlated with the DQ at 12 months despite no significance ($r = .426$, $p > .05$). However, the correlation between the Established month of level I and the DQ at 12 months is low ($r = .358$), and no correlation is found between the Confirmed month of visual representation and either of the 2 months of level I.

DISCUSSION

1. Confirmation of Visual Representation

The Confirmed month of visual representation is much later than those from the previous studies with younger infants (e.g. Fantz, Friedman, etc.). This discrepancy should result from different tasks and procedures in experiments, namely this study with hiding an object at one of three positions and the previous studies with examining younger infants' recognition memory of 2 or 3 dimensional materials.

According to Bower (1974), existence constancy of an object is acquired without manipulation by 5 months of age, while the understanding of "inside relations" is developed after 5 months. However, the existence constancy in about 5 month old infants was not supported by Goldberg (1976). Besides, Uzgiris noted that infants could discover a hidden object with one-hide-position at about 7 months (1975) and locate an object at the same age when it fell out of their view (1973). Therefore, the Confirmed month in this study is considerably verified. Yet further study on its initiation at multiple-hide-positions is needed with younger infants, since this study revealed it even in the 6 month olds.

2. Development of Search Behavior

The three levels of search behavior correspond to behavioral

characteristics at Stage III, Stage IV and Stage V of Piaget's object permanence. Hence, search behavior in this study can be regarded as the behavior based on the representation of location among properties of object concept.

The general developmental process from nonmanipulation to the trial and error one and then to the goal-orienting one is similar to the course of behavior over time at one-hide-position reported by Schofield (cited from Gratch, 1975). Nevertheless, this Sequential pattern was found merely in 2 of the subjects and more than half of them fell in the Redundant pattern. The tasks of Piaget's Stage III and Stage IV are one-hide-position and two-hide-positions, respectively. Consequently, two possible interpretations are considered concerning the Redundant pattern found in many subjects. One is due to the difference of tasks and the other is because the period of the experiment corresponded fairly to the ages of Stage IV.

Most of the subjects repeated the trial and error search behavior across months prior to the Establishment of the goal-orienting one. But none of them showed "place error" of Stage IV except one, and he showed it before the Confirmed month of visual representation. Among different kinds of trial and error manipulations, an unexpected error occurred across months in most of the subjects. The characteristic of this error is manipulating merely one or two not-hiding boxes and persisting in it even after the experimenter took out the hidden object from the box and showed it to the subject at the end of the 25 sec duration. This specific error started in a part of the subjects at 6 months and most frequently occurred in more than half of the subjects at 8 months. Yet the frequency

of occurrence and the number of the subjects were rapidly reduced at 10 months. And then none of the subjects showed it at 12 and 13 months.

As interpretations on "place error", dependency upon action due to infants' egocentrism (Piaget, Gratch), lack of precision in spatial localization (Lucas & Uzgiris, 1977), insufficient memory capacity (Harris, 1973) and so on were mentioned. However, Bremner (1978) recently proved that "place error" was promoted by the previous experience and even 9 month old infants were not always egocentric in search for a hidden object. With reference to his findings, nonoccurrence of "place error" in this study seems to be because of the varied hiding place at each trial. Since the specific error occurred most frequently in more than half of the subjects after their own Confirmed months of visual representation, it can be regarded due to their insufficient memory capacity. In other words, their visual representation was enough for registration of the location where the toy was hidden, but not for its retention. This explanation might be more appropriate to other kinds of trial and error behavior. However, why did they keep manipulating a box even after the toy was shown? The other possible interpretation might be that the stimulus value of a box was dominant for infants over that of a hidden toy. In this case, another question appears on which property of a box is attractive to infants of these ages. Further study is required to examine why this specific error occurred.

Goal-orienting search behavior was established at around 10 months in this study. This result is much later than the 7 months of age indicated by Uzgiris & Hunt (1975) and Jackson et al. (1978). Yet the procedure in the former is hiding an object at one of three places while the infant is

in the process of reaching for it, and the task in the latter is two-hide-positions. Without the specific error described before, the Established month of goal-orienting behavior might have come earlier. Nevertheless, most of the previous studies reported the occurrence of "place error" in the 9 month olds (a review by Gratch). This result, accordingly, can not be regarded as having occurred in too late a month.

A significant sex difference was revealed at 6, 7, 9 and 11 months from the cross-sectional data on development in search behavior. The more frequent occurrence of nonmanipulation in the females at 6, 7 and 9 months and that of goal-orienting manipulation in the males at 11 months were shown. McCall et al. (1977) also found more manipulation in the males during these ages, analyzing the data from a mental development test with more than 40 subjects at each age. In consequence, the sex difference on active manipulation is supposed to be a general tendency around these ages. On the other hand, it is not clear cut why the males showed goal-orienting search behavior more often at 11 months. It might be influenced by the fact that the males more frequently searched for an object in the way of trial and error until 10 months.

3. Cognitive Background of Development in Search Behavior

It was only the Confirmation of visual representation that significantly correlated with DQ. The results showed the low correlation between the Establishment of goal-orienting search behavior and DQ, and no correlation between the Confirmation of visual representation and either of Initiation or Establishment in goal-orienting behavior. These results are supposed due to the repeated occurrence of trial and error search behavior, especially the specific error responses only to not-hiding boxes.

In terms of correlation between object permanence and general mental development measured by standardized tests, Décarie (1965) found it, but Lewis & McGurk (1972) did not. Nevertheless, the cognitive background of development in object permanence can not be denied, because of the limitation of included factors or abilities in mental development tests as indicated by Lewis & McGurk. The data on the specific error in this study, namely its remarkable decrement at 10 months and nonoccurrence at 12 and 13 months, seems to suggest the cognitive basis of development in search behavior. Moreover, the Established month of goal-orienting search behavior is almost consistent with the period reported by Kagan when infants' cognitive development is most activated. Therefore, it is concluded that development of search behavior in this study is embodied cognitive functioning.

SUMMARY

The purpose of this study was to cross-sectionally and longitudinally examine the developmental process of search behavior through visual representation in infancy.

The subjects were 23 Japanese normal infants (11 males and 12 females) and were individually tested once a month from the age of 6 to 13 months in laboratory settings. Small toys and three white opaque cubic boxes were selected as hidden objects and covers, respectively. The subject's spontaneous search behavior was observed after hiding a toy under one of the three boxes on a table. Fixation time to either of the three was measured as well as the whole procedure being videotaped.

The cross-sectional data revealed the general developmental process

of search behavior, namely from nonmanipulation to the trial and error one and then to the goal-orienting one. However, more than half of the subjects fell in a Redundant pattern of development. The mean months of Confirmation in visual representation, and Initiation and Establishment in goal-orienting behavior were 6.8, 8.5 and 10.6, respectively. Nonmanipulation was significantly more observed in the females at early months. Among trial and error behavior, instead of "place error" at Stage IV of Piaget's object permanence, specific error of manipulating only not-hiding boxes occurred in most of the subjects across months. A significant correlation was found between Confirmation of visual representation and DQ at 6 months, but not between Establishment of goal-orienting behavior and DQ at 12 months.

The results were discussed related to the previous studies on object permanence as well as on general cognitive development in infancy.

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Table 1 Definitions

Three Levels of Search Behavior

Level I:	manipulating with fixation only the hiding box and then the hidden toy.
Level II:	manipulating with fixation one or two of the other boxes as well as the hiding box, or manipulating only not-hiding boxes.
Level III:	not manipulating but fixation to the hiding box and/or two other boxes.

Confirmed Month of Visual Representation

The first month when the following A value is significantly higher ($p < .05$ or $p < .01$) than the following B or C value:

$$A = \frac{\text{TFT to the hiding box}}{\text{sum of TFT to each of the three boxes}}$$

$$B = \frac{\text{TFT to one of two other boxes}}{\text{sum of TFT to each of the three boxes}}$$

$$C = \frac{\text{mean of TFTs to two other boxes}}{\text{sum of TFT to each of the three boxes}}$$

TFT: Total Fixation Time

Fixation time was measured immediately after a toy was completely hidden until the toy was seen even partially, or until the end of the 25 sec duration.

Initial Month of Level I

The first month when the search behavior of level I occurred even at a single trial after the confirmed month of visual representation.

Established Month of Level I

The first month when the search behavior of level I successively occurred twice or more starting with the first trial, and then continuing for two or more consecutive months.

Table 2 Statistical Values on Confirmed Month of Visual Representation, and Initial and Established Months in Level I of Search Behavior

	Confirmed month of visual representation			Initial month of level I			Established month of level I		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Sample size	7	6	13	9	8	17	7	7	14
Mean	6.7	6.8	6.8	8.1	9.0	8.5	10.3	11.0	10.6
SD	.70	.69	.69	1.10	1.22	1.24	1.28	1.20	1.29
Range	6-8	6-8	6-8	6-9	7-11	6-11	8-12	9-13	8-13
t value	.238			1.503			.978		

Note. Sample size is the number of the subjects whose data is complete enough for judgement in each category. Either of t values is nonsignificant ($p > .05$, one-tailed).

Table 3 Rank-Order Correlations (Spearman's Coefficient)

Variables	1	2	3	4	5
1. Confirmed month of visual representation	1.000				
2. Initial month of level I	-.011	1.000			
3. Established month of level I	.078	.300	1.000		
4. DQ at 6 months of age	.546*	-.132	.338	1.000	
5. DQ at 12 months of age	.426	-.187	.358	.571*	1.000

Note. Sample size is 11 of the subjects whose data is complete enough for judgement in each variable.

* $p < .05$, one-tailed.

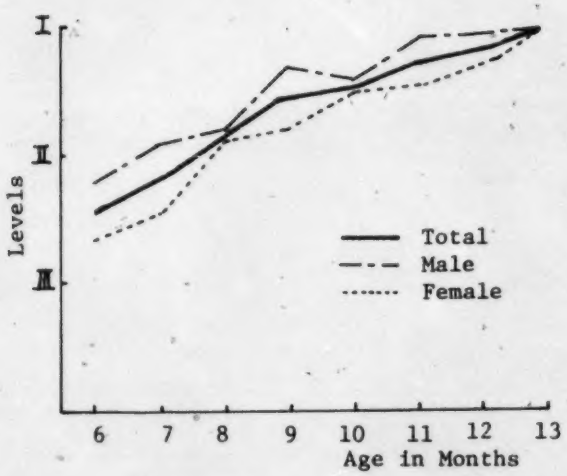
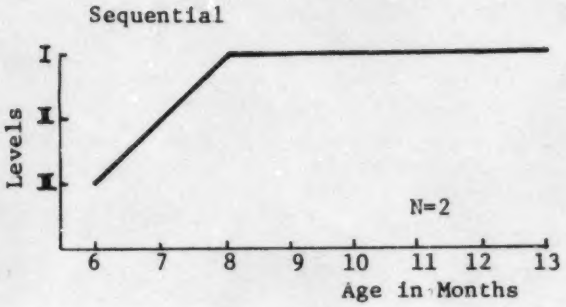
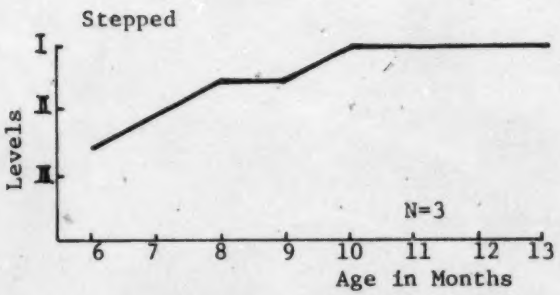
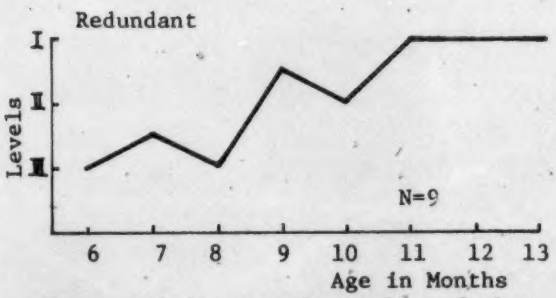


Fig.1 Development of Search Behavior







Note. N indicates the number of the subjects whose data is enough for judgement of patterns.

Fig.2 Modal Developmental Patterns